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Effect of Imposed Self-Governance on Irrigation Rules Design among Horticultural Producers in Peri-Urban Kenya

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Abstract: While high urban vegetable demand has driven unprecedented intensification of small private irrigation in peri-urban Kenya, absence of appropriate local governance mechanisms has necessitated interventions by concerned state agencies. Based on Ostrom's design principles for sustainable commons, this paper evaluates the robustness of the irrigation management regime emanating from involuntary self-governance among peri-urban farmers. Findings show that since conflicts were fueled by water scarcity peaks corresponding with market price peaks, the interventions overemphasized facilitating water sharing among users. With conflicting users viewed as the problem by the agency, their experiences with the resource system, existing social structures, and resource use dynamics causing conflicts were largely ignored in the change process. Consequently, narrowly focused use rules that failed to properly define important resource parameters resulted. Further, user drawing rights have no significant input requirement, monitoring of water resource condition and sanctioning of deviant behavior are overlooked due to a lack of sufficient social capital and commitment to the collective establishment. Although inherent conflicts signify high economic valuation of water access by users, the lack of local ownership of the transition process made the policy interventions fail to produce rules that can guarantee sustainable irrigation development in an environment characterized by intensive irrigation and agrochemicals application, and growing domestic and industrial water demand. Therefore, recognizing water as a commercial input, recognizing conflicting users and their experiences as an essential solution, and integrating them in a participatory manner in subsequent institutional change is deemed necessary for effective governance in the post-conflict setup.

Keywords: institutional arrangements; use rules; common pool resources; participatory irrigation management; water user associations

1. Introduction

In Kenya, horticulture is the most important source of agricultural income, employment, foreign exchange, food and nutrition security and gross domestic product (GDP) [1–5]. The ability of horticultural commodities to drive widespread, market-based livelihood improvement [2,6–8] has increasingly motivated smallholders, defined here as farmers relying predominantly on farming income from parcels of less than 3 hectares, to diversify from staple and industrial crops to the production of these high value crops for incomes, nutrition and livelihoods [2,6,9,10]. In part, declining farm sizes, growing population and food demand, urbanization, globalization, and the volatility of staple and cash crop prices in world markets have increased the attractiveness of horticulture within smallholder production systems [11,12].

The key prerequisite for smallholder horticulture to yield the aforementioned socioeconomic outcomes is investment in productivity-enhancing investments [3]. In particular, to satisfy quality and quantity requirements of most horticultural markets, adapt to the rapidly changing climate, and expand capacity needed to meet supply obligations throughout the year, radical transformation of smallholder farming structures is needed [13,14]. Among others, the changes required are increased use of commercial inputs such as agrochemicals, seeds and fertilizers [15]; increased use of hired labor [16], adoption of improved marketing approaches [17], and improvements in linkages and coordination between production and marketing activities [18]. These changes notwithstanding, intensification of horticultural production, unlike most other crops that smallholders have traditionally cultivated [19], also requires consistent application of significantly larger volumes of water throughout their growth cycle [11,20–25], making irrigation a key antecedent of smallholder commercialization into profitable horticultural production [3,11].

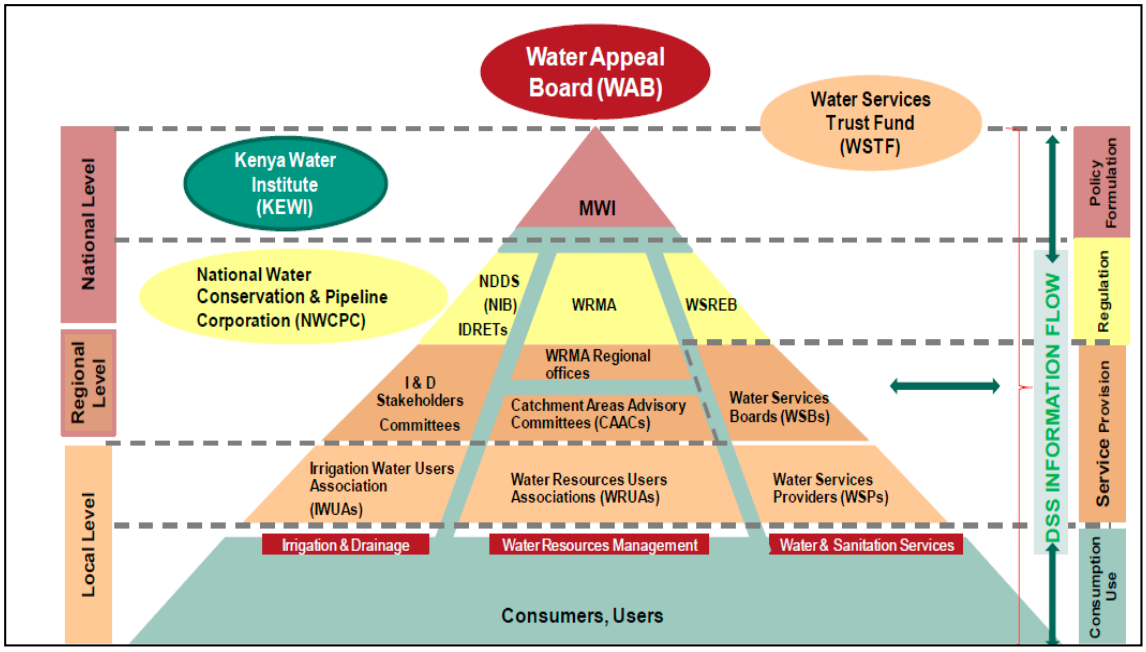
In Kenya, the high water requirement limits the geographic distribution of commercial horticultural production due to skewed spatial and temporal distribution of rainfall and surface water [13,26]. Specifically, the average annual rainfall in the country is low, ranging from 400 mm to 600 mm per annum [11,26]. Second, the rains fall intensively over a short period, not exceeding six months [11], limiting rain-fed horticultural production to less than half of a year. Third, the geographic distribution of surface water resource is highly skewed, with an over-distribution towards the Lake Victoria basin. With the limited temporal distribution and the erratic nature of the rainfall, irrigation becomes a near mandatory value chain input for farmers to reduce the disruptive effects of prolonged dry spells on production, livelihoods, and employment [25–27]). However, due to the skewed geographic distribution of surface water resources, intensive horticultural production is largely concentrated within a 150-km radius of Nairobi city, mostly in the central Kenya highlands [28], where farmers are producing vegetables for both domestic and export markets [11,16,29].

For producers within this region, farm incomes, employment, and poverty levels vary sharply with water availability. For instance, [14] estimates the elasticity of farm incomes to water access at 3.18. Likewise, irrigation investments within these farms are estimated to yield internal rates of return ranging from 17% to 32% [30]. However, despite these high returns to irrigation investments, widespread adoption of irrigation is constrained by lack of public provision of irrigation infrastructure [26], leading producers to resort to investments in small private irrigation systems [25,31–33]. Currently, these small private irrigation systems account for up to 15% of the total irrigated area in the country [11,33,34], and are expected to account for an even larger share of area under irrigation due to their lower cost requirements, higher profitability, and simpler designs compared to larger public irrigation systems [14,26,33].

Numerous studies, [34–39] have comprehensively documented the socioeconomic and livelihood benefits associated with these farmer-owned and operated irrigation systems. The benefits outlined by these authors notwithstanding, appropriateness of irrigation management structures [11,14,27,34,40,41] is the most critical determinant of the long-term success and sustainability of these irrigation systems. The need for effective governance arises because small private irrigation systems are characterized by numerous and individualized points of water extraction which create high risks of resource over-abstraction, degradation and pollution along the intensification continuum, and persistent interruption of the natural course of water flow [34,37]. Further, competition for water allocation between private and public water uses within small private schemes creates demand for resilient and often unique water governance structures [42–45].

In the Kenyan context, water resource use governance is provided for within a polycentric framework operating at national, regional, catchment, and local levels, as shown in Figure 1. A detailed historical account of the transition of irrigation governance in Kenya from a centralized state-run model to the current participatory model is provided by [46–48]. Within the prevailing framework, water policy formulation, implementation, and regulation are undertaken at the national level, while the regulation of water use at regional and catchment levels is left to various parastatal bodies.

The framework unambiguously identifies the mandates of all the water sector actors outlined in Figure 1 [46]. Specifically, and of interest to this study, it assigns the responsibility of water allocation and water basin management, water use conflicts resolution, identification and registration of water users, water use monitoring, and information gathering to the Irrigation Water Users Associations (IWUAs) operating at the irrigation and drainage level.



Key:

MWI—Ministry of Water and Irrigation

NDDS—National Irrigation and Drainage Development Services

NIB—National Irrigation Board

WRMA—Water Resources Management Authority

WSREB—Water Services Regulatory Board

IDRETs—Irrigation and Drainage Research, Extension and Training Service

Figure 1. Participatory water use management framework as provided in Kenya's Water Act. Source: [46].

Unfortunately, due to the underdevelopment of irrigation in Kenya, where only 3% of total cropped area is irrigated, most extant studies have focused on identifying the drivers of irrigation uptake [13,24,49–53] and the welfare impacts of irrigation uptake among smallholder farmers [30,36]. The effectiveness with which irrigation water use management is being carried out by irrigators under the prevailing legal framework has received minimal attention, despite governance being a crucial component of sustainable irrigation development. For the few extant studies that have interrogated irrigation governance in Kenya [48,54–57], none have undertaken an evaluation of irrigation governance within the context of intensive commercial peri-urban horticulture, where water use conflicts have necessitated policy interventions that differ from the traditionally studied irrigation management transfer. It is this gap that we intend to fill by answering two questions: (1) how was irrigation water use being governed in Kiambu before and after the policy intervention? (2) Did the policy intervention yield robustly designed water use governance mechanisms?

2. Materials and Methods

2.1. Study Area and Data

Kiambu is one of the 47 counties in the Republic of Kenya, Figure 2. Located in the central Kenya region, the county is predominantly peri-urban, covers a total land area of 2543.5 km^2 and had a total population of 2,417,735 in 2019. Falling between 1200 and 2550 m above sea level, the county is divided into four broad topographical zones, Upper Highland, Lower Highland, Upper Midland, and Lower Midland Zone. Like other parts of the country, the county experiences a bimodal type of rainfall with long rains falling from mid-March to May and short rains from mid-October to November. The average annual rainfall varies with altitude; with higher areas receive as high as 2000 mm and lower areas receive as low as 600 mm. The average annual temperatures range from 26 °C–34 °C depending on the zone. The western part of the County, where the study sites fall, covers Limuru, Kikuyu, Kiambu, Lari, and Githunguri wards (red circle in Figure 2) which are characterized by fertile high level upland soils, plateau soils and volcanic footbridges soils, and proximity to Nairobi markets. Correspondingly, substantial irrigation-dependent horticultural production is practiced in the study area, driven by the producers' desire to intensify production to meet the high demand of nearby urban markets [15]. It is estimated that up to 74% of vegetable producers in the area have invested in individualized irrigation infrastructure, with at least 64% of irrigating farmers relying on motor-powered pumping from surface and ground sources and conveying the water into the fields through pipes where it was eventually applied using sprinklers [36].

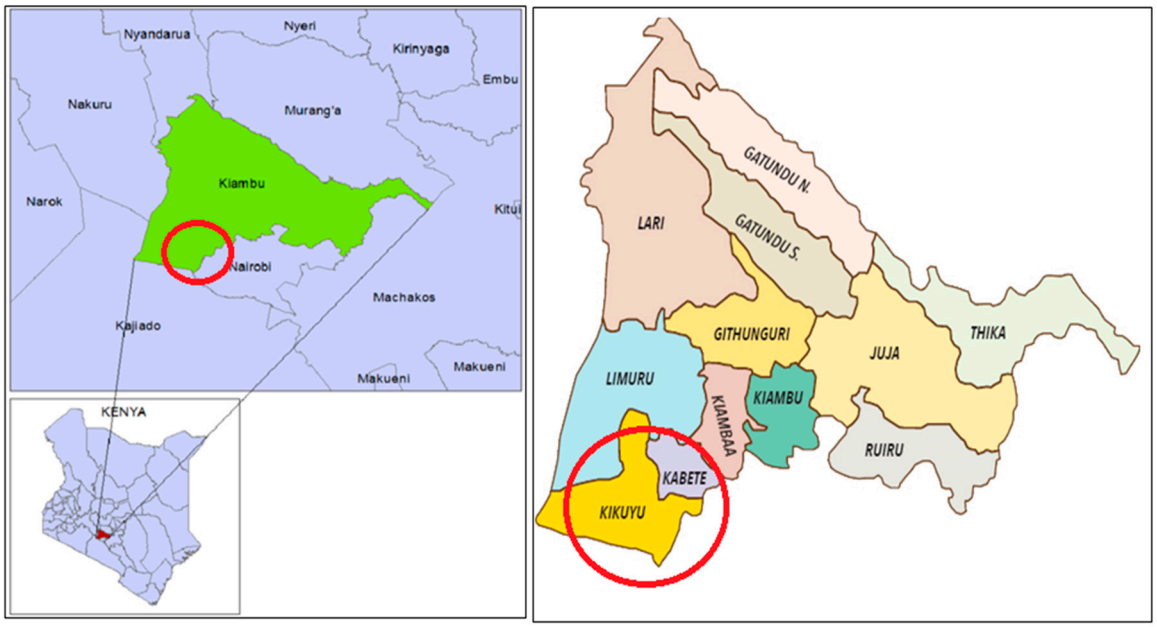


Figure 2. Map of study sites in Kikuyu and Kabete sub-counties, Kiambu County. Source: [58].

2.2. Data Collection

This study is based on a case study of two water user associations, one operational and one defunct, along two streams (Gitangu and Mweteta) in two neighboring villages in Kiambu County. Interviews were conducted with a total of 15 individuals; five members of the operational IWUA, one member from the defunct IWUA, two agricultural extension officers working closely with these farmers, two individual water users beyond the operation area of the two IWUAs, and three vegetable assemblers who were supplying vegetables assembled from the study area to both supermarkets and wet markets outlets. Likewise, field observations, farm visits, transect walks along the streams and photographic images from the vegetable fields form part of data sources. These images were taken after obtaining express permission from farmers and the extension officers for the streams.

Interviews with our respondents focused on the following topics: (1) the chronological evolution of water use demand, governance and conflicts, land use changes, and land market development; (2) the nature of involvement of the community, the local administration, and the government agencies in the management of water resource in the area; (3) the relationships between irrigation water use and the livelihoods of farmers, and the willingness of farmers to pay for the water resource (per unit used and for investment in storage facilities); (4) sustainability concerns that respondents felt were not receiving sufficient attention; (5) distribution of water use benefits along the streams considering the situation with and without the IWUAs and during the wet and dry seasons; and (6) the nature of water use rules, sanctions, and choices that irrigators in the study area are subjected to. In the collection of these data, field notes were taken but in instances where respondents agreed to the use of recording devices, the interviews were recorded in Swahili language using a mobile phone. The notes and transcripts of the translated audio recordings were later coded to identify the various items of interest in the study.

2.3. Framework Used to Analyze Participatory Irrigation Governance in Kiambu

The unprecedented intensification and commercialization of smallholder farming systems in peri-urban Kenya can be explained using the induced innovation theory [14]. According to this theory, population pressure, decreasing land sizes, rapidly increasing urban population and climate change are some of the movers that can explain the transition from rain-fed farming to intensive, irrigation-based smallholder farming (Ibid.). Accordingly, the proximity of Kiambu to Kenya's capital has created opportunities for smallholder vegetable producers in to intensify production. However, their commercialization and intensification depend heavily on increased irrigation application [36], inevitably linking food security, rural employment and livelihoods of irrigators to the accessibility and availability of irrigation water. Unfortunately, since Kenya is classified as a water-scarce country, there exists a need for regulated allocation and application of the available units to sustainably meet the needs of all users and uses.

As a common-pool resource (CPR), irrigation water use governance is a widely studied topic all over the world. See for instance [59–66]. Among the forms of governance outlined in the vast literature, polycentric governance, involving the community of users at the basin and the state or another authority at a higher level has gained prominence and near global acceptability. However, these studies recognize that successful irrigation governance is context-specific, requiring the analysis of the conditions of the resource, the community of users and their socioeconomic conditions, as well as the wider institutional framing within which the users are operating. Nevertheless, from a review of extensive case studies on factors driving success in long-surviving CPRs, Ostrom [67] identified essential elements that constitute optimally structured natural resource governance systems. Referred to as Ostrom's eight design principles, they are simply the established best practices comprising of rules and enforcement mechanisms that when incorporated within the use rules can ensure sustainable use of the common-pool resource in question [56]. This study compares the design principles as outlined by Ostrom [67–70], as reviewed by [71], with the use rules designed in Kiambu to find out whether the existing irrigation governance system in Kiambu County is optimally structured.

To answer the first research question, irrigators and agricultural officials in the study area were asked to provide a historical overview of the development of irrigated farming and the emergence of the need for water use governance. These actors specifically described the water demand situation and its management before and after the intervention of the state. The claims made by farmers were corroborated with the extension officers and vice versa. To answer the second research question, all the rules and sanctions put in place to structure irrigators behavior and relationships among irrigators were documented. After identifying all the rules in use, they were categorized into the 11 categories outlined by Cox et al. [71]. The robustness of the irrigation management regime was evaluated based on the presence or absence of rules covering each of the design principles in Table 1, as outlined by Ostrom and reviewed by Cox.

Table 1. A comparative analysis of Ostrom's design principles against water use rules in Kiambu.

Ostrom's 8 Design Principles	Irrigation Management Condition in Kiambu
Clear boundaries: i. defining legitimate users ii. defining the resource system	Users defined as farmers drawing water from the stream, ignoring community water projects, and irrigators who had sunk boreholes. Resource system defined as stream water, ignoring groundwater sources.
Congruence of use rules: i. with local conditions ii. for appropriation and provision	Use rules do not recognize social differences between users. Use rules define drawing rights, no user input or efforts towards the resource is required.
Collective choice arrangements	Use rules are collectively determined through representation.
Monitoring: i. of the users' behavior ii. of the resource condition	Monitors were mandated by users to ensure compliance with drawing schedule and rules. No monitoring function for resource conditions.
Graduated sanctions	No reprisal for non-compliant irrigators, enforcement of rules dependent on moral suasion
Conflict resolution mechanisms	No clear mechanisms to resolve conflicts among irrigators, or between irrigators and monitors.
Recognition of users' rights to organize	WRA fully recognizes the rules designed by irrigators.
Nested rules and governance	No evidence that appropriation and enforcement rules or conflict resolution mechanisms are either vertically or horizontally nested.

3. Results

3.1. The Economic and Ecological Environments of Smallholder Horticulture in Kiambu

Commercial vegetable farming is an integral component of the smallholder farmers' economy in Kiambu. Owing to the small farm sizes and proximity to Nairobi markets, most of the land and, in some areas, entire farms were under vegetable production, as shown in Figure 3. To satisfy the year-round vegetable demand within Nairobi markets and take advantage of higher prices during dry periods, modern irrigation, comprising of motorized pumps and piped conveyance from streams and wells were being used by at least 63% of the irrigators interviewed. Characteristically, both streams understudy flow from the highlands towards Nairobi in a West-to-East direction, and farmers on either side of the streams and community water projects were drawing water along the stream's course. For the farming community, irrigation application required only access to a water source and ownership of irrigation equipment. There were no formal requirements that farmers needed to adhere to before installing their irrigation equipment, leading to indiscriminate stream diversion into water pans.

(**a**) (**b**)

Figure 3. Intensive irrigated vegetable farming along ustream (**a**) and mid stream (**b**) sections of a stream in Kiambu (note the water pans, power line, and numerous pump stations in the middle ground).

3.2. Evolution of Water Use Management in Kiambu

Although irrigated vegetable farming has been practiced in Kiambu for a long time, the volume of river flow was reported to have drastically reduced over time, while the number of users and uses was increasing. Further, the connection of most households in the study area to the national electricity grid led to irrigators investing in motorized pumps, increasing per-household drawing capacity. Eventually, increased competition among users led to unequal distribution of water and accompanying benefits between upstream and downstream users. Downstream farmers felt that " ... upstream farmers were benefiting too much from a resource which all members of the community were entitled to ... " Specifically, the large reservoirs and pumping capacity of upstream users was the biggest concern since it led to complete flow interruption during the dry spells.

With their livelihoods at risk, downstream farmers felt the necessity of some form of interventions to counteract upstream obstruction. The initial strategy was self-organization and moving along the stream to remove the barricades and diversions put in place by upstream farmers. Unfortunately, this did not help, but only escalated existing conflicts into physical fights. Though these conflicts were initially being referred to area chiefs, their frequency and magnitude eventually led to the local administrators being overwhelmed. In fact, chiefs in upstream villages were being accused of abetting their villagers' actions. With the chiefs arguing that it was not practical to prohibit any farmer from irrigating whereas the river was flowing through their farm, the use-related conflicts spiraled out of control necessitating involvement of the Water Regulatory Authority (WRA).

At first, WRA interventions aimed at ensuring that the streams' flow was restored. To achieve this, WRA in conjunction with agricultural extension officers " ... came to the river and spent days removing the obstructions installed upstream". During this period, "WRA officials ... were [also] advising farmers on how to economically use the available water ... especially drip irrigation instead of overhead irrigation since the latter is more wasteful". However, the attempt of WRA and extension officers to prohibit stream obstruction did not work. As soon as they left the site, the barriers would be re-erected. The persistence of water flow obstruction and use conflicts necessitated WRA to convene a meeting with all irrigators along the two streams. At this meeting, held in Kikuyu town, issues pertaining to water use in the area farming were discussed at great length. As a last resolution of the meeting, farmers utilizing the two streams for irrigation were requested to choose between either working in structured self-regulation or accept direct involvement of WRA in the management of water resources in the area.

According to extension officers present at the meeting, the WRA option would have entailed the installation of water meters at the point at which each farmer was drawing water for irrigation use. Under this option, the water would have been priced and each farmer charged for the volume of water he or she was drawing. Second, before being allowed to continue irrigating, every farmer would have been required to obtain a water-use permit, as per the formal requirements for all non-domestic water uses in Kenya. On the other hand, the self-regulation option was to entail farmers forming IWUAs and designing use rules that would govern irrigation activities along the two streams. The farmers settled for the second option because it had the least economic implications on them and by the end of the meeting two water user associations, Gitangu-Ondiri IWUA and Mweteta IWUA were formed. Under the self-organization and management option, WRA was not to be involved in the direct management of water use along the two streams unless the conflicts persisted. Nonetheless, WRA continued organizing training sessions for officials of the two WUAs to train them on how to better manage water resource use. At formation, the two IWUAs under consideration were replicas of each other, except that membership was drawn from farmers cultivating along the respective streams.

3.3. Participatory Irrigation Management through IWUAs in Kiambu

3.3.1. Operationalization of Water Use Governance by Mweteta IWUA

For effective management of irrigation application along the Mweteta stream, the IWUA segmented users along the stream into three—upper, mid, and lower stream users. A sub-committee was formed for each of these segments, as per the advice of the WRA officers. According to the former official of the group, the farmers had neither agreed with this recommendation nor with the requirement for them to prepare a water use timetable as the tool for managing water application. Members of the group showed a preference for independently determined rules and mode of operation. Due to disagreements over whether the WRA recommendations were voluntary or obligatory, the group ended up " . . . not preparing an actual timetable [and] the water application days were communicated orally without documentation".

Nevertheless, the group operated for some time, with members collectively determining how the water application would be distributed. The upper- and mid-stream groups had been allocated two days in a week to irrigate while the lowermost group had been allocated three days to compensate for a large number of users and lower volumes of water reaching them. Unfortunately, members did not honor the timetable for long and due to lack of mechanisms to enforce agreed-upon use rules, this led to the collapse of the collective initiative. However, before it collapsed, the group was working on a proposal to WRA that all stream users be required to individually obtain a water-use permit from WRA. As per their suggestion, farmers along the stream would not have been allowed to apply for the permits from WRA directly, but rather through the IWUA. This had been proposed to make sure that all farmers were adhering to the laid down use rules before getting a recommendation from the group and that upon obtaining the permit they used the resource appropriately. In the opinion of the former leader of this IWUA, the feeling by members that the IWUA structure was proposed by WRA without giving due consideration to their interests was associable with its collapse.

3.3.2. Operationalization of Water Management by Gitangu-Ondiri WUA

To ease water use governance, Gitangu-Ondiri IWUA was divided into four semi-autonomous sub-committees, each covering a five-kilometer of the stream, starting from the source. Each sub-committee was mandated with monitoring the adjacent group of upstream irrigators to ensure compliance with collectively determined rules. By monitoring the group of users immediately above them, the aim was to ensure that users in close social proximity were policing each other.

For this IWUA, a water application timetable was the main tool used to structure irrigation application. Though drafting of the timetable was recommended by WRA, its preparation was being done collectively at the IWUA level by three representatives from each of the four sub-committees.

Once unanimously agreed upon, the water drawing schedule would then be communicated to the other IWUA members, with each farmer being issued with a copy of the timetable. Notably, the timetable was only prepared and enforced during periods of water scarcity. During the wet seasons, the IWUA was largely non-operational and farmers were free to use the available water as they desired. Likewise, the water users' association and timetable were not operating on a stream-wide scale but only covered the section of the stream where almost all farmers were engaged in intensive irrigation application.

3.3.3. Nature of Water Use Rules and Their Enforcement Mechanisms Designed by Irrigators in Kiambu

The formation of IWUAs in Kiambu was prescribed by WRA with their mandate being to maintain a list of users and ensure reasonable sharing of available water among irrigators during periods of scarcity. This objective was to be achieved through enforcement of a set of collectively determined use rules and a water drawing timetable to be determined by the irrigators. Table 1 shows a comparison of the design principles as defined by Ostrom [67,69] and Cox [71] with the actual rules and enforcement mechanisms put in place in Kiambu.

Owing to the prescription by WRA that IWUAs ensure fair water sharing, the rules formulated by the irrigators were focused solely on defining water drawing rights. This was achieved by defining a 24 h period to each sub-committee to divert water flow from the stream into water reservoirs. However, the 24 h rule was not constant and was often adjusted during periods of acute shortage, when farmers within each section were allowed to draw water for a maximum of three hours. The second irrigation rule prohibited farmers from pumping water directly from the stream. Rather, farmers were required to excavate water pans for temporary water storage. To fill water into these water pans, the third rule required farmers to install an inlet pipe not exceeding two inches in diameter and by no means use inlet tunnels into the reservoir. The rule also required each reservoir to have an outlet leading back into the stream. The fourth rule prohibited the opening of the inlets in contravention of the provision of the water sharing schedule. Owing to the geographic disadvantage of tail-enders, an additional set of rules had emerged. The primary rule required farmers to participate in stream policing, without which they would not be allowed to draw water once it was flowing downstream.

To ensure compliance with the water-sharing schedule, each sub-committee appointed 2–3 members to act as the water sharers. The water-sharing role was voluntary, unpaid, and was held on a rotational basis to avoid situations where the same people shared water for long. The water sharers ensured that inlets into water pans were of the recommended size and that the water timetable was being followed by irrigators along each section. To share water to members in each sub-committee, the water sharers started with the user(s) at the lower boundary of each group. From this point, they diverted stream flow to each farm until the water reservoir was full. Once all water pans were filled up, all inlets were left open and every farmer within the sub-committee was allowed to continue drawing water until the allowed period elapsed.

Concerning compliance, farmers were adhering to the water use timetable and other drawing rules out of their own volition since there were no formal or informal sanctions for non-compliance. Without " ... strict measures taken to ensure that the rules are followed, what we [the officials] do is that we try to convince farmers on the need to follow the laid down rules". However, "people are naturally disobedient. You still find, even with the rules, there are farmers who want to fight over the water". However, with water scarcity experienced only during dry spells, IWUA officials tried to convince farmers " ... not to fight over a transitional problem that will fade away while they [farmers] will remain as members of the society". According to the Gitangu-Ondiri officials, the fact that " ... the users are members of the same community led to most of them adhering to these rules. They [farmers] fear that if they don't, other members of the society will see them in a bad light and people may not cooperate with them if they have a need". Thus, even without formal sanctioning some farmers still followed the collective rules but for those who did not, there was no punishment meted.

3.4. Have the Established Water Use Rules Made Things Better for Irrigators in Kiambu?

The perception of the effectiveness with which the WUAs had improved water sharing among users differed depending on the location of farmers along the stream. Most midstream irrigators felt the IWUA had greatly improved the water situation in the study area. According to one such irrigator, "Were it not for the small rules we have in place, we would never have access to water. The upstream users would never let water to flow downstream during the dry spells." However, farmers further downstream felt that though they were allocated more time to irrigate, very little water was getting to them. Likewise, they had to police nearly the entire length of the stream on the days they were allocated because most upstream users were being dishonest. This was confirmed by IWUA officials who noted that "upstream users are not particularly bothered by downstream users not accessing sufficient water during dry spells. When it is too dry, the upstream users advanced the argument that downstream users are in a more developed peri-urban area where they have constructed rental houses and thus they have a supplementary source of income. They argued that these farmers do not desperately need water as do upstream users who only rely on farming for livelihoods."

One particular challenge noted was that the group of downstream users was the largest of the four sub-committees. As a result, the days allocated in a week to draw water during the dry spells were not sufficient. Further, since the IWUA only recognized farmers drawing water from the stream, a considerable group of farmers had sunk boreholes to circumvent the water use regulation being applied along the river and overcome the problem with river water conflict. According to some respondents, the effect of the drilling was, however, already manifest in the form of the reduced quantity of water in the stream which they associated with " ... interruption of groundwater flow to the stream".

Further, owing to the focus of the IWUA on water sharing, conservation, and protection of the water ecosystem was overlooked. Farmers were unconcerned with the riparian land, with cultivation happening upto the riverbank. From our interviews, it was noted that the river " ... catchment area was initially more than 6 hectares but was encroached and only about 2 hectares were remaining. The water catchment consisted of a communal land reserve ... [which] has since been grabbed and sold to people as private land." Additionally, most farmers considered the requirement to conserve the riparian land as too demanding, arguing that their farms were too small. Nonetheless, some irrigators appreciated the need " ... to grow the right crops that would support biodiversity as well as reduce the surface runoff".

4. Discussion

Small farm sizes, growing urbanization, and proximity to urban markets have increasingly driven horticultural producers around Nairobi to invest in modern irrigation, as a productivity-enhancing technology. With irrigation, the producers have benefitted significantly from the lucrative opportunities presented by both formal and informal urban markets [36]. Unfortunately, as irrigation has gained importance as a vegetable value chain input and self-provision as the primary source of irrigation provision, competition among users has increased dramatically, leading to conflicts over the increasingly valuable resource. Although an attempt was made to address the animosity and resource conflicts caused by the high water demand, the effectiveness of the resultant institutional arrangements designed by users remains unknown despite irrigation uptake being on the rise in Kenya and the sustainable irrigation development being shown to depend on the existence of effective institutional design [11,40]. Given that the latter has been identified as a principal challenge in most smallholder irrigation systems in sub-Saharan Africa (SSA) [13,34] this study sought to identify whether the irrigation governance approach in commercial smallholder horticulture in peri-urban Kenya is robustly designed, given the fact that self-governance among irrigators was coerced rather than voluntary.

According to McGinnis and Ostrom [70], achieving this objective, and in particular understanding the irrigators' choice of irrigation management regimes, requires an understanding of the incentive structure facing the irrigators at hand, and the kind of choices they are likely to make given their

conditions. Mwangi and Crewett [36] provide an overview of the incentive structure behind irrigation explosion in Kiambu, linking incremental irrigation intensification with better marketing outcomes and farmer livelihoods in the study area. It is, therefore, not surprising that these irrigators felt a need for some form of regulated irrigation application when socio-economic strains caused by increasing water scarcity, competition, and unequal distribution of water disrupted the lucrative vegetable market system. Consistent with the hypothesis that reaching a resource threshold would necessitate use governance [70], water demand surpassing supply in Kiambu necessitated regulated use, but only seasonally.

As in most other African communities [72], irrigators in Kiambu initially resorted to solving water use disputes using indigenous mechanisms, in particular through local administrators. Over time, however, as urban fresh produce demand expanded, water resources acquired a significant commercial value, making the local mechanisms unsuccessful avenues for resolving the use struggles. With the connection of most of the households in the study area to the national electricity grid, farmers invested substantially in electricity-driven pumping stations, further expanding water demand but leading to complete failure in local mechanisms, necessitating intervention by WRA.

The WRA facilitated the formation of IWUAs and mandated them with the management of irrigation water use, enforcement of collectively determined rules, and resolution of water use conflicts, in line with provisions of Kenya's Water Act. However, despite similar participatory approaches having led to successful governance of common-pool resources like communal pastures, forest resources, water systems, and fishing grounds in many parts of the world [69], in Kiambu, the WRA approach failed in two respects. First, it failed to recognize already existing social entities such as vegetable marketing groups, instead requesting the formation of new associations. Second, the functions of the newly formed IWUAs were narrowly prescribed as maintaining a register of stream water users, preparing and enforcing water distribution schedules, and resolving conflicts between users. With focus externally determined and narrowly focused, the participatory approach failed to incorporate the lessons and experiences irrigators had accumulated over many years, eventually resulting in rules that do not resemble those observed in successful CPR situations [69,70].

Specifically, in the design of robust rules, clearly defined boundaries are needed, describing what constitutes the resource system, what constitutes the resource use, and who the authorized users are. In our study case, though an attempt was made to achieve this, the stream "stakeholders" were defined as farmers drawing water from the streams for irrigation purposes. This narrow definition left out community water projects drawing water from the same streams, farmers cultivating within the Ondiri swamp, farmers who had sunk boreholes and water users further downstream. By leaving so many users outside the resource boundary, all the aspects requiring governance and all potential beneficiaries are not clearly defined [69]. As a result, loopholes exist for irrigators to avoid being governed by drilling boreholes and wells, which are faultily outside the boundaries of the water resource system. Likewise, the interests of the aquatic life, downstream users and the wider stream and Nairobi river ecosystems were not given due consideration.

Second, succinctly defined use rules are needed defining how, when, where, and how much of the resource benefits users can appropriate and the benefits the users ought to provide to the resource system in return. Since the irrigators in Kiambu were concerned with resource appropriation, most of the rules in use were focused towards defining these parameters. Specifically, it was crisply clear when and how irrigators were allowed to draw water during designated days as per the collective agreement. Unfortunately, though the rules defined the maximum inlet capacity, the maximum water volume a farmer could draw during the designated period, the maximum rating allowed for the installed pumps, the size of the water pan to be excavated were not defined. As a result, allocating water until the water pans were full, and in most cases when the pump stations were still running, did not equitably distribute the resource. Well-off farmers, in terms of land size and pumping capacity, benefitted more than those with lesser endowments. Likewise, the rules failed to define the input irrigators were required to provide into the resource system for conservation and maintenance.

Third, robust use rules are supposed to be collective, such that the individuals to be bound by them are involved in their determination. With collectively determined rules, the irrigators would associate and agree to be bound with them more easily than in cases where the rules are externally determined. This was an inherent strength of the participatory rule-setting approach in Kiambu, in that use-rules were jointly determined through representation. Each sub-committee selected several officials who aggregated to form the decision-making organ of the IWUA. These representatives met at predetermined intervals or on-demand and formulated the collective rules, which were then communicated to irrigators. Each sub-group was also free to make own rules where necessary to assist in the effective administration of the wider rules. However, these facts notwithstanding, the collapse of the Mweteta IWUA was associated with a lack of freedom by irrigators to fully self-determine. For irrigators along this stream, a different approach other than the blanket WRA recommendation was perceived. Without WRA giving due consideration to irrigators' needs and inputs, the irrigators eventually failed to implement the WRA recommendation, putting the resource system and user livelihoods at the risk.

The fourth design principle of sustainable commons requires the monitoring of the resource situation and user behavior to be undertaken for or by the users. This principle was well taken into consideration when designing the governance structures in Kiambu, with irrigators assigning the monitoring function to the water sharers and sub-committee officials at each section of the river. The water shares were expected to monitor users within their section for compliance with the drawing rules and to police upstream sub-committees to ensure that no farmers were drawing water dishonestly. Unfortunately, the resource condition was of no interest to the irrigators and thus the monitors, since irrigators desired only to share available resource units and not to improve or sustain the resources' overall health.

In Kiambu, however, even though user drawing behavior was monitored, the best the monitors could do was take corrective action in the form of disconnecting water flow into the farms where farmers were drawing illegally. If such noncompliance continued, the officers could not do anything due to the absence of sanctioning mechanisms. Without access to sanctioning mechanisms, the irrigators also lacked effective and low-cost means of resolving water use conflicts, indicating a failure of the fifth and sixth design principles. Only the fear that more punitive irrigation rules by WRA would apply if water use conflicts persisted made farmers observe rules. Likewise, the desire to remain a member of good social reputation made some irrigators comply with the rules. Even so, since the water scarcity peak coincides with market price peaks, the desire to make more money from irrigation seemed to overshadow the desire to be socially responsible and acceptable, leading to non-compliance among some irrigators.

The seventh design principle requires that government authorities recognize the participants' right to self-organize and govern, effectively giving the collectively determined rules formal acceptability. Undoubtedly, the irrigators' right to self-govern was clearly provided for, with IWUA being responsible for overall management of sub-basin level water use and conflict resolution. However, the lack of input and autonomy in choosing how to structure their self-governance structures can be attributed to the failure of both IWUAs to evolve into effective irrigation management vehicles. Through stakeholder forums with irrigators, WRA can, however, provide an opportunity to farmers to discuss and determine the aspects of water use to be governed and how to do it as long as it is done consistently with existing laws. This would make the process truly participatory and the resulting structures would have local ownership and formal recognition. In particular, it would provide an opportunity for nesting of local rules to the formal institutional setup.

5. Conclusions and Recommendations

This study evaluated how participatory irrigation governance is implemented in Kenya and whether robust irrigation governance has resulted from a case of commercialized peri-urban farming. Findings show that due to the individualistic and spontaneous nature of the physical irrigation

infrastructure development, no accompanying institutional investments were made, creating a near governance vacuum when the resource scarcity necessitated regulated use. In a bid to institute order and resolve conflicts fueled by growing water demand, WRA intervened, compelling users to form IWUAs that were mandated with irrigation governance and conflict resolution.

Unfortunately, this institutional change occurred through a process that failed to recognize the social structures existing among the irrigators, leading to a lax attitude towards resource use governance and rules that only advanced the commercial interests of irrigators. Important resource governance considerations, such as equitable water distribution, protection of the river ecosystem from agrochemical pollution and degradation, were of no immediate interest to these irrigators. Likewise, governance was narrowly perceived and defined by irrigators as sharing available units among the conflicting users, completely ignoring the wider stream ecosystem. Further, seasonal governance, aimed at resource sharing during periods of scarcity was adopted, leading to a discontinuity of governance.

Due to the lack of local ownership in the institutional change process, the rules in use were not institutionalized, rendering them unenforceable. More unfortunately, the resource monitoring function was limited to monitoring of user behavior, while monitoring of resource condition was completely ignored.

This situation notwithstanding, the same irrigators were observed to work in well-structured marketing setups, indicating that high social capital and collectivism exist. Unknown to them, however, is that water resources are not unbounded and without local ownership of irrigation governance, the ability of the stream ecosystem to sustain the commercial vegetable value chain and farmer livelihoods remains highly uncertain. Since a comparison of the design principles observed in robust CPR situations and those of irrigation governance in Kiambu show significant deficiencies in the water use rules and their enforcement mechanisms, WRA ought to involve the irrigators more constructively, paying attention to the attitudinal deficit. By making irrigators aware that self-governance is being instituted for them and not against them, rules that clearly define the resource boundary, users and uses, rules that safeguard the resource against pollution from heavy agro-chemicals application, and rules that address ongoing altering of the land gradient and siltation will be realized. Further effective sanctioning and enforcement of water drawing rules, equitable distribution and investments in water resource system improvement can be expected when the users become active stakeholders in the process of institutionalizing of use governance.

To this end, an urgent need also exists to incorporate irrigation water use management as an integral part of the ongoing irrigation expansion in other parts of the developing world. The adaptive co-evolution of irrigation infrastructure development and use rules is likely to produce better economic and ecological outcomes than responsive governance, as witnessed in Kiambu. It is also clear that creating entirely new social structures under duress may not offer a lasting solution in a resource conflict situation. Due consideration on ways of integrating existing social establishments is needed for participatory irrigation governance to yield the desired outcomes in a post-conflict setup.

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